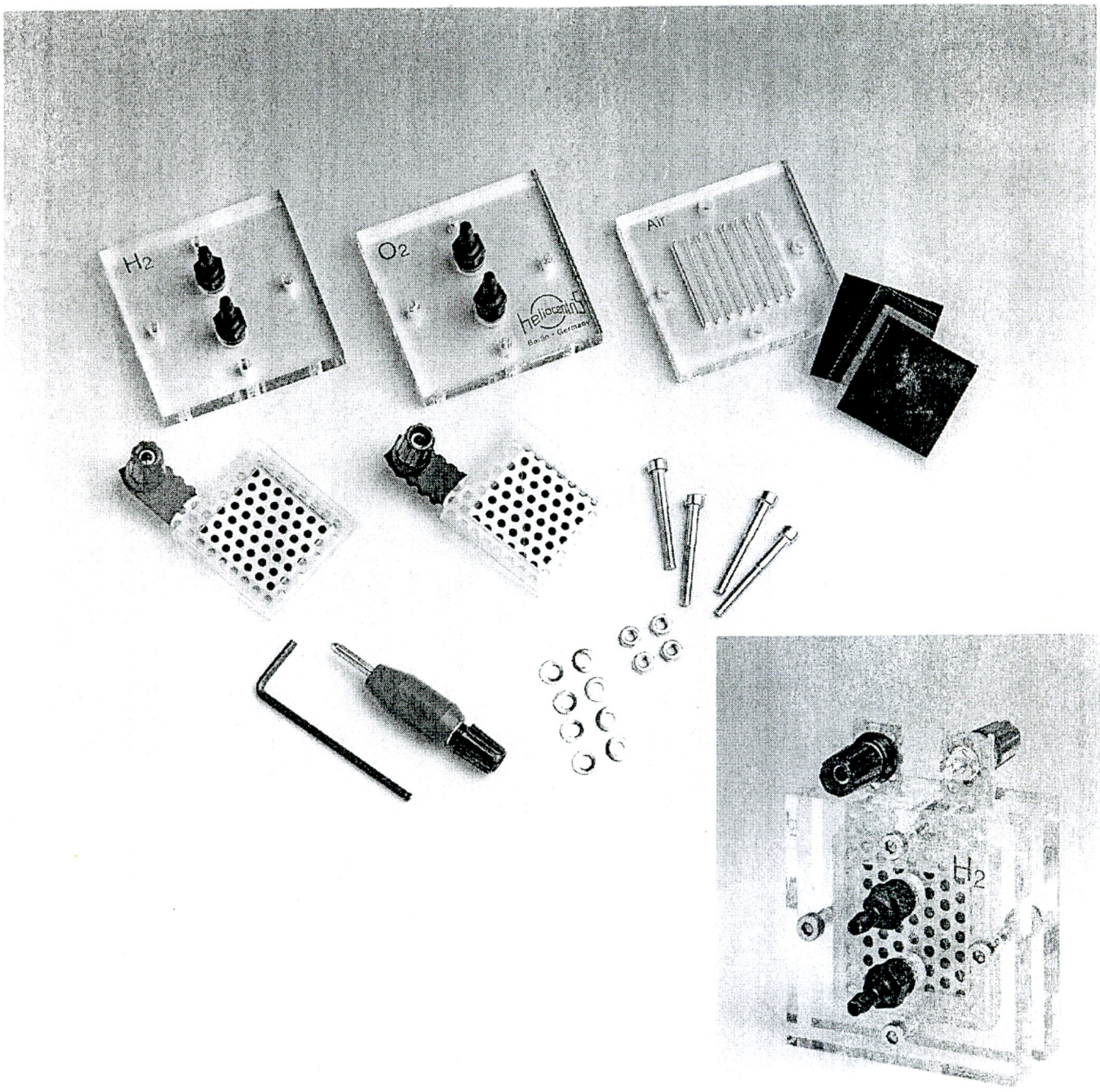
Operating Instructions



Dismantable Fuel Cell Extension Kit

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Operating Instructions Dismantable Fuel Cell Extension Kit, October 99 model and later.
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1. Notes for the User

The following symbols are used in the operating instructions to indicate dangers and references:

Dangerous situation (serious injuries possible)

User tips

Danger of explosion

No open fire

Wear protective goggles

Smoking prohibited

2. Safety

2.1. Introduction and Safety Information

Improper operation or abuse can lead to dangers for

- the health of the operator
- the unit itself and other items of property.

All persons involved in the setting up, operation and maintenance of the unit must

- read and precisely follow these operating instructions
- be fully trained for/instructed in their work.

The following symbols and signal words are used in these operating instructions:

Warning!

Draws attention to a potentially dangerous situation.
Serious injuries can occur if this reference is ignored.

Important!

Draws attention to application tips and other useful pieces of information. This is not a reference to dangerous situations. A risk of damage to the product or to the environment might be involved, however.

2.2. Correct Use

The hydro-Genius™ Dismantable Fuel Cell Extension Kit is an experimentation model on hydrogen technology and is part of the hydro-Genius™ Science Kit family. It may only be used for experimentation and demonstration purposes and must be operated in accordance with these operating instructions.

The enclosed experiment instructions describe in detail the procedure to be followed in the experiments and contain additional safety information. They should be treated as part of these operating instructions.

The hydro-Genius™ Dismantable Fuel Cell Extension Kit may not be used for generating electricity for general use, e.g. for operating electrical devices or equipment.

Use only components contained in the Science Kit and the Dismantable Fuel Cell Extension Kit for the experiments unless the attached experiment descriptions expressly permit the use of other components.

Unauthorised modifications or changes to the components are prohibited for safety reasons. The operating and maintenance conditions laid down in these operating instructions must be observed.

2.3. Sources of Danger

Source of danger ⇓ **Possible consequences**	**Precautions**
Use of hydrogen ⇓ Danger of explosion 	Avoid handling ignition sources or open fire in the vicinity of the model. Smoking is strictly prohibited.

2.4. Authorised Operators

You may only work with the Dismantable Fuel Cell Extension Kit if you

- have read the operating instructions,
- have been instructed on proper handling by the operator,
- have been informed about the potential dangers involved in connection with the unit

The hydro-Genius™ Dismantable Fuel Cell Extension Kit may only be used by trained teaching staff or by pupils and students under the supervision of teaching staff. As the teacher you must ensure proper handling. You are obliged to draw attention to potential dangers.

The experiment instructions and illustrated set-up instructions must be handed out before starting an experiment with pupils.

Take measures to prevent unauthorised persons from installing, using or maintaining the unit. If the hydro-Genius™ Dismantable Fuel Cell Extension Kit is passed on to a third party, you must also pass on the operating instructions.

2.5. Workplace

The components of the hydro-Genius™ Dismantable Fuel Cell Extension Kit must be assembled and operated on an even, horizontal, stable and solid base.

A working height of 75 - 85 cm is recommended for experimentation purposes

The model needs approx. 1.0 m x 0.5 m of space.

The ambient temperature should be between 10°C and 35°C. We therefore recommend that you only operate the model inside the building in order to protect it from the weather.

2.6. Protective Equipment

All people present during experiments must wear protective goggles.

3. Technical Data

3.1. Contents of the Package

Dismantable fuel cell, consisting of:

- end plate for hydrogen
- end plate for oxygen
- 2 current collector plates with carbon gas distributors and tip jacks
- membrane electrode assembly coated with 0.3 mg of catalyst per cm^2
- end plate for operation with ambient air
- membrane electrode assembly coated with 0.1 mg of catalyst per cm^2
- plug-in resistance 0.47 Ω
- 3 mm hexagonal socket screw key (Allen key) and 7 mm spanner
- 2 silicon tubes
- 2 spacers (plastic tubes ∅ 7 mm)
- Documentation: Operating instructions
  Experiment instructions
  Illustrated assembly instructions

3.2. Necessary Expendables

Hydrogen gas, purity at least 99.9 % (3.0) from one of the following sources:

1. Electrolyser of the hydro-Genius™ Solar Hydrogen Technology Science Kit or the hydro-Genius™ School Electrolyser
2. Hoffmann water-splitting apparatus
3. 1-litre pressure bottle of hydrogen
4. Compressed-gas cylinder

3.3. Available Additional Accessories

Solar Hydrogen Technology Science Kit, with solar module, electrolyser, fuel cell and load measurement box.

course instruction books, 3-volume set, teacher's handbook

3.4. Basic functions

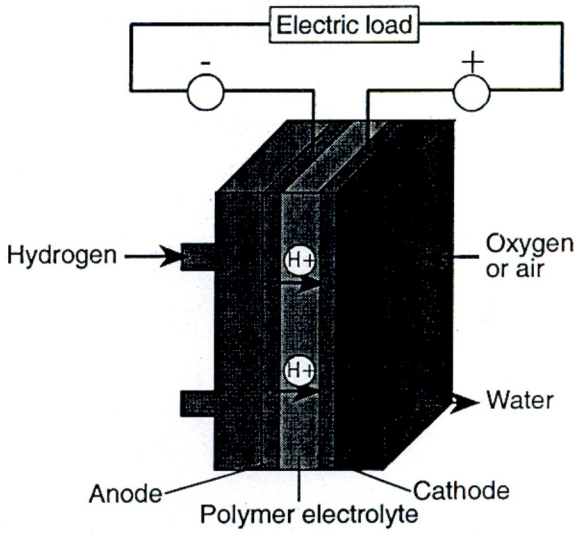
The hydro-Genius™ Science Kit, Solar Hydrogen Technology is a miniature solar-hydrogen plant which has been specially devised for teaching purposes. The components are identical to those used in solar-hydrogen off-grid power-supply plants.

This Extension Kit deals with the how fuel cells work and the parameters that influence a fuel cell's output.

It is designed as part of the Science Kit, although it can be operated independently.

This is how the dismantable fuel cell works:

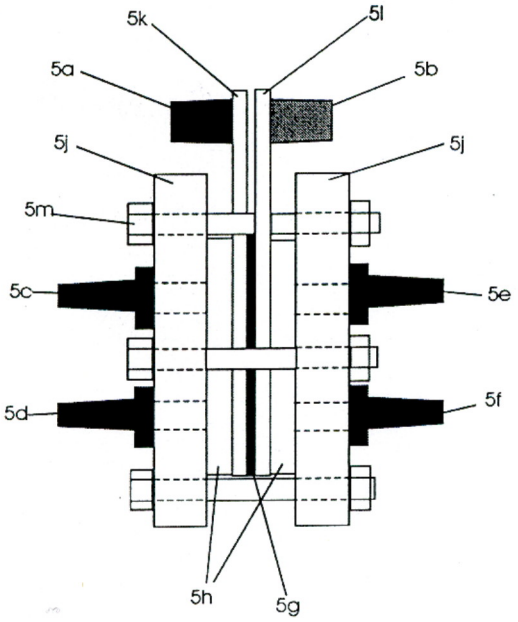
1. At the anode, hydrogen is catalytically oxidised to protons (hydrogen ions).
2. Electrons are released to the external conductor. They drive the electric load (e.g. electric motor or bulb) and flow to the cathode.
3. The protons pass through an ion-conducting membrane separating the anode area from the cathode area.
4. At the cathode, the protons react with oxygen to form water, absorbing electrons.



The following parameters of the cell can be varied by mounting the respective accessories:

- The speed of the catalytic reaction can be influenced by using a second membrane electrode assembly with a thinner catalyst coating.
- The fuel cell can be operated using either pure oxygen and oxygen from the air. A second end plate has been specially designed for operation with air.
- A plug-in resistance simulates a higher internal resistance of the fuel cell.
- The influence of these parameters on the characteristic curve and power of the fuel cell can be investigated, thus giving a detailed understanding of the factors that influence the quality of a fuel cell.

3.5. Overview



5a	Tip jack negative terminal
5b	Tip jack positive terminal
5c	Hydrogen inlet nozzle
5d	Hydrogen outlet nozzle
5e	Oxygen inlet nozzle
5f	Oxygen outlet nozzle
5g	Membrane Electrode Assembly (MEA)
5h	Gaskets
5j	End plates
5k	Current collector plate, negative terminal
5l	Current collector plate, positive terminal
5m	Mounting screws

3.6. Technical Data

Fuel cell

Dimensions (width x height x depth))	65 mm x 65 mm x 85 mm
Voltage	0.4 – 0.9 V
Current (oxygen operation)	max. 2000 mA
Current (air operation)	max. 1300 mA
Hydrogen consumption	7 ml/min at 1000 mA of current

Climatic conditions

Ambient temperature	10 - 35 °C
Transport and storage temperature	10 - 35 °C. Protect against frost!

4. Transport and Storage

The Dismantable Fuel Cell Extension Kit is delivered ready-assembled. Please contact your dealer in the event of any transport damage.

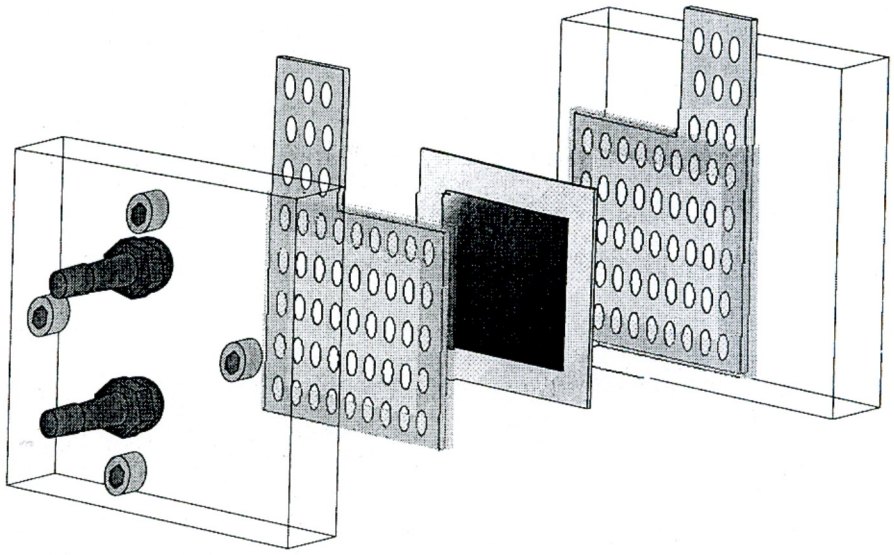
The best place to store the Dismantable Fuel Cell Extension Kit is in its designated compartments in the storage container belonging to the Solar Hydrogen Technology Science Kit.

5. Dismantling and Assembly

The Dismantable Fuel Cell Extension Kit is delivered with illustrated assembly instructions. Please hand these out to the pupils to enable them to set up the unit properly. The following sections contain written assembly instructions.

Before dismantling the unit, please read the safety advice in section 2.

For dismantling and assembly you will need the 3 mm hexagonal socket screw key (Allen key) and a 7 mm spanner (included in the initial delivery).



Dismantling the fuel cell

1. Place a clean sheet of paper under the unit.
2. Remove all 4 screws.
3. Unscrew and remove the 4 nuts and washers.
4. Pull the 4 screws with washers out of their mounting holes.
5. Carefully lift out one of the two acrylic side pieces.
6. Carefully remove the electrode unit consisting of the two metal plates and the membrane between them.
7. Take hold of the two contact plates at their contacts (sheathed with shrinkdown plastic tubing) and carefully pull the contact plates apart.
8. Pull the membrane electrode assembly (MEA) off. Make sure you only touch the surrounding gasket frame of the MEA.

Important !

Never touch the MEA directly with your fingers.

The dismantling of the fuel cell is now complete.

Assembling the fuel cell

1. Insert the 4 screws with washers from the outside into the end plate on the hydrogen side (marked H_2).
2. Align the current collector plate on the hydrogen side (5k) (black shrinkdown plastic tubing) on the acrylic cover between the 4 screws with the tip jack pointing outwards.
3. Thread 2 of the screws through the membrane electrode assembly (MEA) and position the MEA in the middle of the current collector plate.

Important !

Never touch the MEA directly with your fingers.

4. Align the current collector plate on the oxygen side (5l) (red shrinkdown plastic tubing) on the MEA with the tip jack pointing outwards.
5. Put the second end plate (marked "O_2" or "Air") in place.
6. Place the washers onto the visible ends of the screws.
7. Add the 4 nuts and tighten them all by hand until they are hand tight. Make sure that the two end plates are aligned parallel to each other.
8. Tighten all the screws using the 3 mm Allen key and the 7 mm spanner (both enclosed) until the distance between the two plates is 7 mm at the screws. Use the two enclosed spacers (plastic tubes) to ensure correct positioning.

The assembly of the dismantable fuel cell is now complete.

The power of the dismantable fuel cell can be slightly influenced by cautiously changing the pressure of the two acrylic plates on the membrane electrode assembly (MEA).

The two nozzles on the oxygen side (marked O_2) must not be removed during air operation, since this might cause serious sealing problems after reassembly. The enclosed air plate should be used to increase output during air operation.

The enclosed experiment instructions contain further information on how to perform the experiments with the Extension Kit. Follow these instructions to ensure that you conduct your experiments safely and reliably.

6. Operation of the hydro-Genius™ Dismantable Fuel Cell Extension Kit

6.1. Using the right operating media

If possible, use the electrolyser of the hydro-Genius™ Solar Hydrogen Technology Science Kit or one of the hydro-Genius™ School electrolysers as your source of hydrogen and/or oxygen.

Start up the electrolyser as described in the respective operation instructions. Connect the electrolyser's hydrogen tube to the dismantable fuel cell's hydrogen inlet nozzle (5c) and (if you intend to work with oxygen) the electrolyser's oxygen tube to the oxygen inlet nozzle (5e). Approx. 5 minutes after starting up the electrolyser, the fuel cell will deliver its full electric energy.

Fur further information please consult the experiment instructions and the electrolyser operation instructions.

6.2. Information on gas from other sources

You can also use other gas sources, but this should be done with particular care. If gas sources other than the hydro-Genius™ electrolysers are connected to the dismantable fuel cell, heliocentris will assume no liability for any damage thus caused. Please follow the operation instructions of the respective gas source.

a) Hoffmann water-splitting apparatus

The hydrogen for operating the dismantable fuel cell can be produced in a similar way to the electrolyser by using the Hoffmann apparatus.

The Hoffmann apparatus must be operated according to the appropriate operating instructions.

The Hoffmann apparatus may only be filled with sulphuric acid (H_2SO_4). **Other electrolytes can lead to the destruction of the fuel cell.**

Make sure that no electrolytic solution from the Hoffmann water-splitting apparatus gets into the fuel cell.

The dismantable fuel cell is working properly if the electrolysis current amounts to at least 100 mA.

b) 1-litre pressure bottles of hydrogen

The dismantable fuel cell can be supplied with hydrogen from a laboratory pressure bottle.

Pressure bottles with a volume of 1 litre and a filling pressure of 12 bar are available from heliocentris.

Be sure to use a **pressure reducer** with an ultimate pressure of no more than 0.6 bar for the gas supply, since the hydro-Genius™ dismantable fuel cell is not designed for operation under pressure.

Connect the fuel cell's hydrogen inlet nozzle (5c) to the pressure reducer of the pressure bottle with a rubber tube.

In order to monitor and adjust the hydrogen flow, the rubber tube fixed to the fuel cell's gas outlet (5d) should be dipped into a beaker filled with **distilled** water.

Adjust the hydrogen flow in such a way that as little hydrogen as possible escapes through the gas outlet. One bubble per 2 – 5 seconds is sufficient.

If the hydrogen supply is smaller than the amount consumed, distilled water will be drawn out of the beaker into the fuel cell. The gas flow must be readjusted every time the current delivery of the fuel cell is increased.

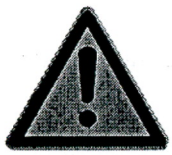
The rubber tube must be removed from the beaker as soon as the source of hydrogen is turned off.

c) Compressed-gas cylinder

The hydro-Genius™ dismantable fuel cell can also be operated using a common laboratory compressed-gas cylinder with pressure reducer, in a similar way to the pressure bottle.

The purity of the hydrogen must be at least 99.9% (purity 3.0).

Please follow the operating instructions of the pressure reducer and the compressed-gas cylinder.



Please note: the hydro-Genius™ Dismantable Fuel Cell is not designed for operation under pressure. When regulating the pressure, the pressure reducer must be handled with extreme caution, in order to avoid sudden pressure surges.

Be sure to follow the safety instructions in sections 2 and 6.

6.3. Safety Precautions for Operation

1. The teacher is responsible for ensuring that pupils and other persons only operate the model under supervision and after receiving instruction.
2. Experiments with hydro-Genius™ Dismantable Fuel Cell Extension Kit must be carried out according to the enclosed experiment instructions and/or those provided with the hydro-Genius™ Solar Hydrogen Technology Science Kit.

6.4. Recommended Modes of Operation

Regular operation is good for the hydro-Genius™ Dismantable Fuel Cell. If possible, the equipment should be used for several hours every 3-4 weeks. The more frequently the fuel cell is used, the more efficient it is. The membrane can dry out if the unit is not used for a long time. The model will then take longer to start up.

In order to ensure that measured data of the fuel cell (e.g. for the characteristic curve) correspond to the data indicated in the experiment instructions, the fuel cell should be in operation for some time before the measurements are made.

6.5. Improper Modes of Operation

1. The gas outlets of the fuel cell and of all tubes may only be sealed while precisely following the experiment instructions.

2. Do not under any circumstances connect the fuel cell to an external power source (e.g. laboratory power supply unit or solar module). A forced current flow from outside can immediately lead to the destruction of the fuel cell.

6.6. Possible Malfunctions

(Minor faults which you can remedy yourself)

The electric load has not started operation after 10 minutes / The ammeter indicates that no current is flowing	Are the fuel cell and the electric load connected correctly?
	Is the electric load (e.g. motor) suitable for the voltage of the dismantable fuel cell?
	Check whether the stoppers on the electrolyser and rubber tubes leading to the fuel cell are tight and impervious.
	If gas bubbles can be observed in the electrolyser, a fuel-cell tube might be leaky.
	The fuel cell might have dried out if the Science Kit has not been in operation for more than 2 months. In this case, introduce a few drops of distilled water into the fuel cell's oxygen inlet nozzle using a wash bottle.
	Surplus water can collect in the fuel cell during continuous operation. It can be poured out occasionally through the nozzles.

All other faults and irregularities can only be remedied by heliocentris.

Please notify your dealer in such an event by telephone or by fax.

Many questions can be clarified by phone. A decision can then still be taken subsequently on whether the hydro-Genius™ Dismantable Fuel Cell Extension Kit or individual parts of it need to be sent in for repair.

6.7. Closing Down Operation

1. Remove all cables and tubes.
2. Store all the components in their designated compartments in the storage container belonging to the Solar Hydrogen Technology Science Kit. Check the packaging instructions in the storage container.
3. Store the container in a safe place that is protected against unauthorised access.

6.8. Closing Down Operation in an Emergency

Proceed as follows in the event of unexpected operating conditions:

Leaking hydrogen ignites	Immediately remove the power lead from the electrolyser to stop hydrogen production. Initiate all necessary fire-fighting measures. Immediately ensure that everyone keeps a safety distance of at least 10 m from the model. Approach the model after a waiting period of at least 10 minutes with suitable protective clothing (protective goggles!) and close down operation of the model according to section 6.7.

If this happens, send the Dismantable Fuel Cell Extension Kit in to the manufacturer to be checked before starting up again.

7. Maintenance and Servicing

7.1. Safety Precautions

Make sure that all rubber tubes and cables are correctly fitted after maintenance work.

Please follow the safety instructions in section 2.

7.2. Cleaning

Use only clear water or a special acrylic glass cleaner to clean the Dismantable Fuel Cell Extension Kit. No cleaner liquid must be allowed to enter the components. **Be sure to avoid all contact with solvents.**

When cleaning, be careful to not damage the components by using too much force.

8. Warranty and Complaints

The guarantee period for the hydro-Genius™ Dismantable Fuel Cell Extension Kit is 6 months. The guarantee period begins on the day of delivery and only covers faults that occur in the context of proper use through no fault of the operator.

Warranty claims shall be deemed invalid if:

1. the customer caused the damage by maloperation.
2. the equipment has been arbitrarily repaired or manipulated.
3. the customer has neglected his/her duty of supervision, and damage has been caused by third parties.

Your dealer shall be liable for damage caused during delivery to the customer and shall ensure replacement in the event of damage.

The customer shall bear the risk and costs in the event of complaint and the return of the Science Kit for repair, and must ensure proper and safe packaging.

In all cases of questions, please contact your dealer.

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